Design Element			Manual Section	Two-Way DHV 2900-2050 (1)	Two-Way DHV 2050-1250 (1)	Two-Way DHV < 1250 (1)
Design Controls	Highway Type		—	TWS-6	TWS-4	TWS-2
	Design Forecast Year		31-4.02	20 Years	20 Years	20 Years
	*Design Speed (2a)		48-2.01	30 mph – 45 mph	30 mph – 50 mph (2b)	30 mph – 40 mph
	Access Control		35-1	Consider Managed Access	Consider Managed Access	Consider Managed Access
	Level of Service		31-4.04	C	C	C
	On-Street Parking (3)		48-2.05	Not Recommended	Not Recommended	Not Recommended
Cross Section Elements	*Surface Width	Without Parking	34-2.01	2@ 38' e-f	2@ 26' e-f	30' f-f
		With Parking - 1 Side (4)		1 @38' e-f 1 @46' e-f	1 @ 26' e-f 1 @ 34' e-f	36' f-f
		With Parking - 2 Sides (4)		2 @ 46' e-f	2 @ 34' e-f	44' f-f
	Auxiliary Lanes	Lane Width	34-2.03	Single Left & Right: 12', Min. 11' m Dual Lefts: 24', Min.: 22'		
		Curb Type and Width		B-6.12 or B-6.24 CC&G (5)		
	Bicycle Lane Width (Shared) (6)		Chp. 17	Min.: 13'	Min.: 13'	Min.: 13'
	Cross Slope	*Travel Lanes	34-2.01	1/4"/ft for Two Lanes Adjacent to Median (7a)	1/4"/ft for Two Lanes Adjacent to Median	1/4"/ft for Lanes Adjacent to Crown (7b)
		Auxiliary Lanes		—	—	—
	Outside Curb Type & Width		34-2.04	B-6.24 CC&G	B-6.24 CC&G	B-6.24 CC&G
	Median Width	Flush/TWLTL	34-3	11', 12', 13' (8)		
		Traversable TWLTL		16'		N/A
		Raised-Curb		18', 22', 30'		N/A
		Depressed		—	44' - 50'	—
	Sidewalk Width		48-2.04	5' with Buffer Strip Behind Curb	5' with Buffer Strip Behind Curb	5' with Buffer Strip Behind Curb
	Clear Zone		38-3	(9)	(9)	(9)
Roadway Slopes	Side Slopes	Cut Section (Curbed)	34-4.04	—	—	—
		Rock Cut	34-4.05	—	—	—
		Fill Section (Curbed)	34-4.02	—		
	Median Slopes	Concrete Surface/Traversable	34-3	3/16"/ft	3/16"/ft	N/A
		Flush/TWLTL Surface		1/4"/ft	1/4"/ft	N/A
		Grass Surface		5/8"/ft (Towards C&G)	5/8"/ft (Towards C&G)	N/A

TWS = Two-Way Street, e-f = edge of median to face of curb, f-f = face of curb to face of curb

* Controlling design criteria (see Section 31-8).

GEOMETRIC DESIGN CRITERIA FOR SUBURBAN/URBAN TWO-WAY ARTERIALS
(New Construction/Reconstruction)
(US Customary)

Figure 48-6A

Design Element			Manual Section	Two-Way DHV 2900-2050	Two-Way DHV 2050-1250	Two-Way DHV < 1250
Bridges	Highway Type		—	TWS-6	TWS-4	TWS-2
	New and Reconstructed Bridges	*Structural Capacity	N/A	HS-20	HS-20	HS-20
		*Clear Roadway Width (10)	39-6	76′ plus Median Width	52′ plus Median Width	30′
	Existing Bridges to Remain in Place	*Structural Capacity	N/A	HS-20	HS-20	HS-20
		*Clear Roadway Width (11)	39-6	70′ plus Median Width	48′ plus Median Width	28′
	*Vertical Clearance (Arterial Under) (12a)	New and Replaced Overpassing Bridges	39-4	14′-9″ (12b)		
		Existing Overpassing Bridges		14′-0″ (12c)		
		Overhead Signs/ Pedestrian Bridges	33-5	New: 17′-3″ (12b) Existing: 16′-9″		
	*Vertical Clearance (Arterial over Railroad)		39-4.06	23′-0″		

* Controlling design criteria (see Section 31-8).

GEOMETRIC DESIGN CRITERIA FOR SUBURBAN/URBAN TWO-WAY ARTERIALS
(New Construction/Reconstruction)
(US Customary)

Figure 48-6A (Continued)

(1) Traffic Volumes. The design hourly volumes (DHV) are calculated using a PHF = 1.0; adjust these values using local peak-hour factors.

(2) Design Speed.

a. Consider using a minimum 40 mph (60 km/h) design speed in relatively undeveloped areas where economics, environmental conditions, and signal spacing permit. The statutory speed limits in urbanized areas is 30 mph. Before the posted speed limit can be increased, complete an engineering study (Phase I report) and a speed study.

b. Only consider the 50 mph (80 km/h) design speed in open-suburban areas. Do not place curb and gutter adjacent to the edges of the traveled way.

(3) Minimum Street Width. The minimum width of a two-way, two-lane street is set at 30 ft (9.2 m) f-f which allows two-way traffic to pass a stalled vehicle.

(4) Parking Lane Width. The desirable width of the parking lane is 10 ft (3.0 m) and includes the 2 ft (600-mm) gutter width. The minimum width is 8 ft (2.4 m) e-f.

(5) Gutter Width. Under restricted conditions, the gutter width adjacent to the edge of the turn lane may be narrowed or eliminated adjacent to a 12 ft (3.6 m) lane and narrowed adjacent to a 11 ft (3.3 m) lane.

(6) Bicycle Lane Width. Width of a shared bicycle lane is dependent on the posted speed of the street. For a posted speed of 45 mph, use a 14 ft (4.2 m) width, and for posted speeds less than 45 mph, use a 13 ft (4.0 m) width.

(7) Cross Slope.

a. For the third lane away from the median, increase the cross slope by 1/16″/ft (0.5%).
b. For reconstruction projects, an existing 3/16″/ft (1.5%) cross slope may remain-in-place.

(8) TWLTL Median Width. Use a 13 ft (4.0 m) wide median width if there is a significant number of trucks making left turns.

(9) Clear Zone. For curbed facilities, the minimum horizontal clearance to an obstruction is 1.5 ft (500 mm), measured from the face of curb.

GEOMETRIC DESIGN CRITERIA FOR SUBURBAN/URBAN TWO-WAY ARTERIALS (New Construction/Reconstruction)

Footnotes for Figure 48-6A

(10) New and Reconstructed Bridge Widths. Clear roadway bridge widths are measured from face to face of outside curbs or parapet walls. Urban bridge widths are defined as the sum of the approach traveled way widths, the width of the gutters, and the width of the median. A sidewalk or bikeway will result in additional bridge width. For proposed sidewalks on a bridge, add 5 ft (1.5 m) to each side of the bridge. Parking is prohibited on bridges.

(11) Existing Bridge Widths to Remain in Place. Clear roadway bridge widths are measured from face to face of outside curbs or parapet walls. At least one sidewalk must be carried across the bridge. Add a minimum 5 ft (1.5 m) for the sidewalk width.

(12) Vertical Clearance (Arterial Under).

a. The clearance must be available over the traveled way and flush or traversable median.
b. Table value includes allowance for future overlays.
c. A 14 ft 0 in (4.3 m) clearance may be allowed to remain in place with consideration for reconstruction to a clearance of 15 ft 0 in (4.5 m).

GEOMETRIC DESIGN CRITERIA FOR SUBURBAN/URBAN TWO-WAY ARTERIALS
(New Construction/Reconstruction)

Footnotes for Figure 48-6A
(Continued)

Design Element		Manual Section	Design Speed			
			30 mph	40 mph	45 mph	50 mph
*Stopping Sight Distance (1)		31-3.01	200′	305′	360′	425′
Decision Sight Distance (2)		31-3.02	620′	825′	800′	890′
Intersection Sight Distance (3)		36-6	335′	445′	500′	555′
*Minimum Radii	e_{max} = 6% (open-roadway)	32-2.03/48-5	N/A	N/A	N/A	835′
	e_{max} = 4% (open-roadway)		N/A	N/A	N/A	930′
	e_{max} = 4% (low speed)		230′	490′	665′	N/A
*Superelevation Rate		48-5/32-3	e_{max} = 4% (4a)			e_{max} = 6% or 4% (4b)
*Horizontal Sight Distance		32-4	(5)			
*Vertical Curvature (K-values	Crest	33-4	19	44	61	84
	Sag		37	64	79	96
*Maximum Grade	Level	33-2.02	8%	7%	6%	4%
	Rolling		9%	8%	7%	5%
Minimum Grade		33-2.02	Desirable: 0.5% Minimum: 0.3% (with Curb and Gutter)			

* Controlling design criteria (see Section 31-8).

Footnotes:

(1) Stopping Sight Distance. Table values are for passenger cars on level grades.

(2) Decision Sight Distance. Table values 30 mph and 40 mph are for the avoidance maneuver on an urban street (speed/path/direction change) and for 45 mph and 50 mph for a suburban street.

(3) Intersection Sight Distance. Table values are for passenger cars. See Section 36-6 for trucks.

(4) Superelevation Rate:

a. For reconstruction projects with a design speed ≤ 45 mph, a maximum superelevation rate of 6% may remain in place.
b. The superelevation rate of 6% only may be used in open suburban areas.

(5) Horizontal Sight Distance. For a given design speed, the necessary middle ordinate will be determined by the radius of curve and the required sight distance.

ALIGNMENT CRITERIA FOR SUBURBAN/URBAN ARTERIALS
(US Customary)

Figure 48-6C

48-4 FLUSH OR TRAVERSABLE TYPE MEDIANS

48-4.01 TWLTL Guidelines

The applicability of a TWLTL is a function of the traffic conditions that result from the adjacent land use. Evaluate the area to determine the relative attractiveness of a flush median as compared to a raised-curb median. For example, a TWLTL may perpetuate more strip development. When this is not desirable, use a raised-curb median. For additional information on the use of a TWLTL design or flush alternating left-turn lanes along a street, see NCHRP 395 *Capacity and Operational Effects of Midblock Left-Turn Lanes* and Figures 34-3C and 34-3D. Also consider the following guidelines:

1. General. Only provide TWLTL in:

   - areas with a high number of existing driveways per mile (km) (e.g., 10-35 driveways total per mile (20-55 driveways total per km) on both sides of street);
   - areas of existing high-density commercial development;
   - areas with substantial mid-block left turns; and/or
   - areas where space is not available for raised-curb median widths and a need for left-turn lanes exists.

2. Highway Type. Two-lane and four-lane undivided urban or suburban arterials are the most common candidates for the implementation of a TWLTL design. Once these streets are reconstructed, they are commonly referred to as three-lane and five-lane facilities, respectively.

3. Traffic Volumes. Traffic volumes and the percent of left turns in each direction are a significant factor in the consideration of a TWLTL. Use a 20-year design for traffic volumes. As general guidance, consider the following:

   a. Two-Lane Facilities. On existing two-lane roadways, a TWLTL design will often be advantageous for traffic volumes between 5,000 and 14,000 ADT.

   b. Four-Lane Facilities. On existing four-lane undivided highways, a TWLTL will often be advantageous for traffic volumes between 10,000 and 40,000 ADT. The 40,000 ADT value assumes left-turn percentages less than or equal to 30%.

   c. Six-Lane Facilities. The decision on whether to provide a TWLTL or a raised-curb median will be determined on a case-by-case basis. See Section 48-3.03 for guidance.

d. Pedestrians. Pedestrian crossing volumes are also a consideration because of the large paved area that must be traversed when a TWLTL is present (i.e., no pedestrian refuge exists). There may be significant delays for vehicles at signalized intersections to accommodate pedestrians having to cross the highway in one movement. A raised-curb median may provide a refuge area for pedestrians to cross the highway in two movements.

4. Speed. The design speed of an urban street is a major factor in TWLTL applications. Experience indicates that design speeds from 25 mph to 45 mph (40 km/h to 70 km/h) will properly accommodate TWLTL operations. For design speeds higher than 45 mph (70 km/h), the use of TWLTL is not recommended.

5. Crash History. On urban or suburban arterials without medians, traffic conflicts often result because of a significant number of mid-block left turns combined with significant opposing traffic volumes. This may lead to a disproportionate number of mid-block, rear-end, and/or sideswipe crashes. The inclusion of a median for left turns is likely to reduce these types of crashes. Review and evaluate the available crash data to determine if disproportionately high numbers of these crashes are occurring.

6. Advantages and Disadvantages. Figure 48-4A summarizes some of the advantages and disadvantages of a TWLTL median design.

48-4.02 Design Criteria

48-4.02(a) Median Width

Existing highways that warrant the installation of a TWLTL are often located in areas of restricted right-of-way, and conversion of the existing cross section may be difficult. To obtain the TWLTL width, the designer may have to consider the following:

- reducing the width of existing through lanes and analyzing side road radius returns,
- eliminating existing parking lanes and reconstructing curb and gutter and sidewalks,
- eliminating existing shoulders and ditches,
- eliminating existing buffer areas behind curbs and reconstructing curb and gutter and existing sidewalks,
- acquiring additional right-of-way to expand the pavement width by the amount needed for the TWLTL and sidewalks, and/or
- removing an existing raised-curb median.

49-4 URBAN ARTERIAL HIGHWAYS AND STREETS

49-4.01 Application

Section 49-4 is applicable to resurfacing, rehabilitation, and restoration (3R) projects on the State highway system that are:

- urban arterials,
- marked urban highways or streets functionally classified as collectors, or
- expressways (project-by-project basis).

49-4.02 Scope of Work

A 3R project on an urban arterial highway or street may include work such as lane widening, the addition of auxiliary lanes, channelization, median installation, revision of median type, median widening, resurfacing in conjunction with appropriate widening, new or replaced curb and/or gutter, curb ramps to meet the accessibility criteria, pavement markings, landscaping, lighting, and any associated utility adjustments. Except for relatively short sections, 3R work does not include the addition of continuous through lanes that change the basic number of lanes throughout the project.

Other than widening the traveled way, much of this work may also be included in resurfacing only projects. Widening and resurfacing or resurfacing only, in general, should also include any associated improvements necessary to ensure adequate structural support for the new pavement. Widening and resurfacing and resurfacing of parking lanes, replacement of curbs and gutters, sidewalk construction/ replacement, curb ramps to meet accessibility criteria, and other work performed on municipally maintained facilities will be subject to State policy on joint participation improvements as discussed in Chapter 5.

Where considerable amounts of right-of-way will be acquired along a significant length of the project to accommodate widening and resurfacing, most geometric design criteria should be in accordance with the reconstruction requirements of the applicable chapters in this *Manual* (e.g., Chapter 48). Some highway elements may be designed to criteria consistent with restricted site conditions and 3R objectives.

49-4.03 Design Speed

Design speeds for 3R projects on urban and suburban arterials may be the regulatory speed limit when appropriate. A regulatory speed of 45 mph (75 km/h) is the maximum design speed where (1) a two-way left-turn (TWLT) lane is used in the street/highway design, and (2) continuous curbing is used along either edge of the traveled way.

49-4.04 Roadway Cross Section Elements

For uncurbed urban and suburban arterial facilities, the criteria in Section 49-3.03 for rural facilities will apply. Typical practice is to resurface existing curbed pavements with through lanes of 10 ft (3.0 m) or wider (e-e) or turning lanes (e-f), TWLT lanes (e-e), and parking lanes 8 ft (2.4 m) (e-f) or wider without widening except on Designated Truck Routes (DTR). On DTR routes, prepare special studies to support retaining through lanes less than 11 ft (3.3 m) (e-e) wide.

Where widening will be accommodated within the existing right-of-way or where right-of-way acquisition is minimal, the cross section elements may be consistent with site conditions. Under these conditions, through and TWLT lanes may be striped as 11 ft (3.3 m) and other auxiliary lanes may be 10 ft (3.0 m) wide. Parking lanes may be 8 ft (2.4 m) wide.

49-4.05 Capacity

Design capacities, at a minimum, should be adequate for current traffic at a level of service D.

49-4.06 Diagonal Parking

Parking (existing or proposed) should generally be parallel and adjacent to the curb. Diagonal parking may be permitted to remain if a brief engineering analysis of the existing angle parking is included in the Phase I report and the analysis clearly demonstrates that there will be no adverse effect on street capacity and safety. The analysis must describe parking characteristics, crash history, and an observation of street operations and potential problems. See Chapter 48 for more information.

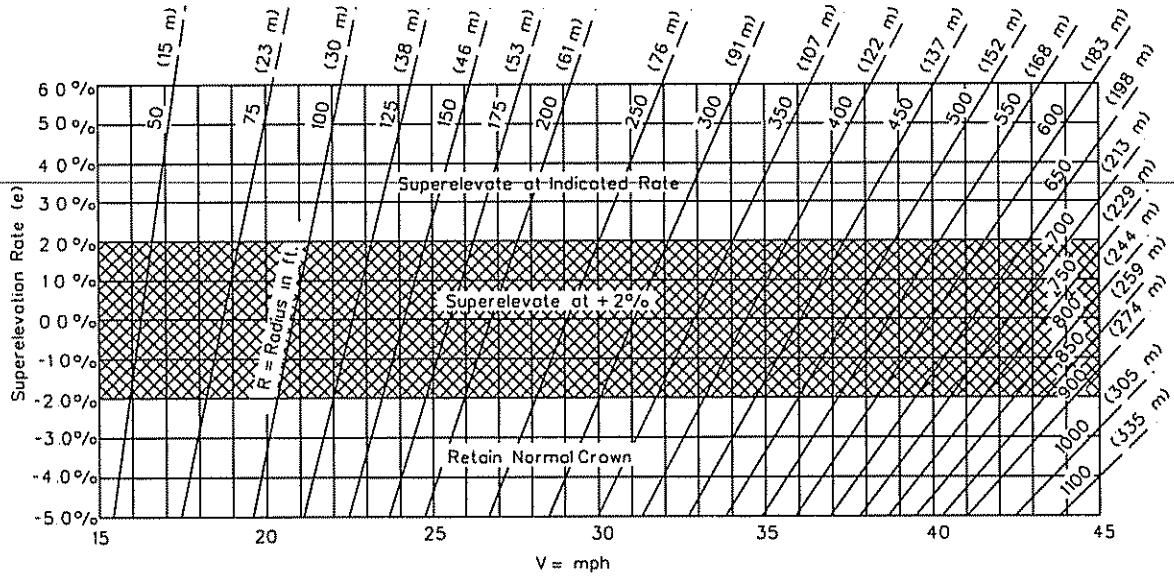
49-4.07 Horizontal Alignment

49-4.07(a) V = 50 mph (80 km/h)

Where the design speed equals 50 mph (80 km/h), the horizontal alignment criteria in Section 49-3.04 for rural arterials will apply to urban arterial 3R projects.

49-4.07(b) V ≤ 45 mph (70 km/h)

For low-speed (V ≤ 45 mph (70 km/h)) urban streets, the designer will use Figure 49-4A to determine the acceptability of existing horizontal curves. Where a horizontal curve will be improved (i.e., flatten the radius and/or increase the superelevation), the designer will also use Figure 49-4A for the reconstructed horizontal curve.



Notes:

1. *The figure provides a range of curves in feet (meters) and superelevation rates which are used to determine a comfortable operating speed.*

2. *AASHTO Method 2 is used to distribute superelevation and side friction for low-speed urban streets. Therefore, the basic point-mass equation applies:*

$$R = \frac{V^2}{15\,(e/100 + f_{max})}$$

Where: R = *curve radius, ft*
V = *speed, mph*
e = *actual superelevation rate, percent*
f_{max} = *assumed maximum side-friction factor (low-speed urban streets) for selected speed, decimal*

3. *For curves that fall within the shaded area, remove the adverse crown slope through the curve. This will ensure that the maximum comfortable side-friction factor is not exceeded due to a negative slope in one direction of travel. It will also minimize potential rollover of trucks (on dry pavement) with low rollover thresholds and minimize possible skidding of trucks with smooth tires on polished, wet pavement surfaces.*

4. *The maximum superelevation rate for new construction is 4%. For reconstruction and 3R, a maximum rate of 6% may be considered to remain in place.*

HORIZONTAL CURVES TO REMAIN IN PLACE
(Low-Speed Urban Streets)

Figure 49-4A

The basic objective for improving conditions on the existing horizontal alignment of low-speed urban streets (V ≤ 45 mph (70 km/h)) is to retain the existing alignment and to check for comfortable operating speeds by using Figure 49-4A. This figure assumes the use of AASHTO Method 2 for the distribution of side-friction and superelevation to determine the appropriate superelevation rates in conjunction with existing radii and posted speeds. See Section 48-5 for more information.

49-4.08 Vertical Alignment

The vertical alignment criteria in Section 49-3.05 for rural arterials will apply to urban arterial 3R projects.

49-4.09 Intersections

The intersection criteria in Section 49-3.06 for rural arterials generally will apply to urban arterial 3R projects. In addition, the following will apply.

49-4.09(a) Turning Radii

In urbanized areas, right-turn maneuvers at intersections are critical for two reasons. One is the speed at which the design vehicle can make a right turn from the main road onto a side street; the second is how much encroachment, assuming the selected design vehicle, will occur into opposing lanes when the design vehicle makes a right turn onto the main road. For right turns at urban intersections, the following guidelines should be considered for 3R projects:

1. Simple radii of 15 ft to 25 ft (4.5 m to 7.5 m) are adequate for a passenger car design vehicle. These radii may be retained on existing side streets:

    - where very few trucks are expected to turn into the side street,
    - where encroachment by a single unit or tractor/semitrailer unit into opposing lanes of the main road is acceptable, or
    - where a parking lane is present and parking is restricted a sufficient distance from the intersection thereby providing a larger area for a right-turn maneuver.

2. Where practical, use a simple radius of 30 ft (9 m) or a two-centered curve at all major intersections and at all minor intersections with some frequency of truck turning volumes. This design will provide for the single-unit vehicle and the occasional tractor/semitrailer unit.

3. At intersections where tractor/semitrailer combinations and buses turn frequently, provide a simple radius of 40 ft (12 m) or more or a two-centered curve.

49-4.09(b) Curb Cuts/Ramps

Curb cuts/ramps shall meet the accessibility criteria in Chapter 58.

49-4.09(c) Intersection Sight Distance (ISD)

At urban, public road intersections with a two-way stop condition or at signalized intersections where right-turn-on-red is allowed, provide ISD along the arterial for the regulatory or posted speed. Use a distance of 14.4 ft (4.4 m) from the edge of the traveled way to the eye of the stopped motorist. Refer to Chapter 36 for details on ISD.

49-4.10 Roadside Treatment and Highway Appurtenances

Clear zones along urban arterials are as follows:

1. Where the arterial is curbed, no obstacles should be located closer than 1.5 ft (500 mm) from the face of curb. This distance is not considered a clear zone, but an operational offset. Make every effort to provide the clear zones of a rural cross section. Where parallel parking lanes are included, a 1 ft (300 mm) clearance to the face of curb may be considered.

2. Where the arterial has a rural cross section, minimum clear zone widths should be:

   - 18 ft (5.5 m) or the non-traversable ditch if less, where the regulatory speed is equal to 50 mph (80 km/h);
   - 10 ft (3 m) where the regulatory speed is 45 mph (75 km/h); or
   - the shoulder width where the regulatory speed is 40 mph (65 km/h) or less.

3. For the treatment of roadsides and highway appurtenances other than described above, as appropriate for the cross section, refer to Section 49-3.07.

   - Where pedestrian traffic is significant, breakaway sign and light supports should not be used.
   - Where the removal of trees may adversely affect the roadside environment, such trees should be removed only when necessary for reasons of safety.

49-4.11 Railroad Crossings and Signals

The criteria in Section 49-3.08 for rural arterials will apply to urban arterial 3R projects.

49-4.12 Bridges

49-4.12(a) Bridge Condition Reports/Structure Sketches

The information in Section 49-3.09(a) for rural arterials will apply to urban arterial 3R projects.

49-4.12(b) Criteria for Bridges to Remain in Place

Urban bridges may remain in place:

- where they meet the structural requirements for rural bridges (Section 49-3.09(c)) including those requirements for decks and bridge rails;
- where the clear roadway bridge width is sufficient to accommodate the number of approach lanes; and
- where the clear roadway bridge width includes traffic lanes 10 ft (3 m) or wider.

For urban bridges, bridge deck repairs similar to those cited for rural bridges may be undertaken. However, bituminous resurfacing carried across bridge decks is restricted as with rural bridges.

49-4.12(c) Criteria for Improved Bridges

Urban bridges that do not meet the criteria to remain in place should be improved. Such improvements shall include the following:

- The bridge shall meet the structural requirements of improved rural bridges (Section 49-3.09(d)).
- The bridge shall accommodate the number of lanes and the median on the approach roadways.
- The bridge shall provide lane widths equal to those on the roadway approaches but not less than 11 ft (3.3 m).

Parking lanes on the approach roadways usually are not carried across urban bridges.

49-4.12(d) Vertical Clearance

The minimum vertical clearance for bridges to remain in place is 14 ft (4.3 m). Economics may dictate exceptions.